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APPLICATION FOR LETTERS PATENT

for

RADIUSED LEADFRAME

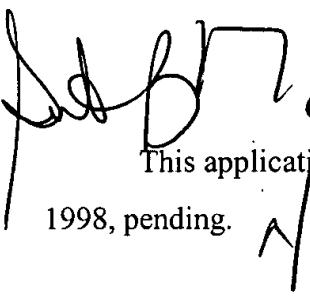
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TITLE OF THE INVENTION

RADIUSED LEADFRAME

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of application Serial No. 09/004,214, filed January 9, 1998, pending.

BACKGROUND OF THE INVENTION

Field of the Invention: The present invention relates generally to integrated circuit semiconductor chips. More particularly, it pertains to leadframes for bonding with the integrated circuits.

Integrated circuit manufacturers face many design challenges, including reducing the amount of noise in the integrated circuit. Resistance, capacitance and inductance, parasitics of an integrated circuit package, can result in increased signal delays and signal distortions in the electrical signals transmitted to and from the integrated circuit.

Two sources of noise in an integrated circuit package are switching noise and crosscoupling noise, or crosstalk. Switching noise may be an inductive voltage spike that occurs on a conductive path as the result of rapid current switching in the conductive path. Crosstalk is the undesirable appearance of an electrical current in a conductive path as a result of mutual capacitance and inductance between the conductive path and other nearby conductive paths. At higher frequencies, the integrated circuit is even more susceptible to noise.

One approach to reduce noise in an integrated circuit is to increase spacing between transmission lines, such as leads of a leadframe 100 as shown in Figure 1. The individual leads 110 forming a right angle are curved in a small portion of the lead and have tightly radiusled corners 118. However, as integrated circuits and electronic equipment become smaller and more complex, spacing transmission lines farther apart becomes increasingly difficult, if not impossible.

Another approach to reduce noise is to reduce the length of the transmission line on a leadframe by using diagonal leads. While diagonal leads minimize the length of the leads, the spacing between the leads would also be decreased. The decreased spacing would increase the overall crosstalk between the leads, and would therefore be undesirable.

Accordingly, there is a need for an integrated circuit package in which the above benefits are achieved and the above problems overcome.

BRIEF SUMMARY OF THE INVENTION

The present invention solves the above-mentioned needs in the art and other needs which will be understood by those skilled in the art upon reading and understanding the present specification.

A leadframe is provided comprising, in part, a first and second set of conductors. The leadframe is adapted for coupling with a semiconductor integrated circuit. The conductors of the leadframe extend radially from a first end to a second end such that a portion of each conductor has a generally arcuate shape between the first and second end. In one embodiment, the first end of the conductor is for coupling with a printed circuit board, and the second end is for coupling with a semiconductor die. Alternatively, each conductor is sized and spaced such that the line spacing remains constant.

In another embodiment, the conductors have a plurality of segments. Each conductor has at least three segments disposed between the first end and the second end. The segments forming the conductors are disposed such that a portion of each conductor generally has an arcuate shape. In another embodiment, the segments each have substantially the same length. Alternatively, the segments have varying lengths.

In one embodiment, an integrated circuit package is provided comprising a leadframe having a plurality of leads, at least one semiconductor die coupled with the plurality of leads, and an insulating enclosure encapsulating the die and a portion of the leadframe. The leads each extend radially from a first end to a second end such that a portion of each lead has a generally arcuate shape. Alternatively, in another embodiment, the leads each have at least three segments disposed between the first end and the second end.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 is a top plan view illustrating a conventional leadframe having leads with tightly radiused corners;

Figure 2 is a top plan view illustrating a leadframe constructed in accordance with one embodiment of the present invention;

Figure 3 is a top plan view illustrating a leadframe constructed in accordance with another embodiment of the present invention;

Figure 4 is a top plan view illustrating an integrated circuit package constructed in accordance with one embodiment of the present invention; and

Figure 5 is a top plan view illustrating a leadframe constructed in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the spirit and scope of the present invention. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

A portion of a leadframe 200 is illustrated in Figure 2. The leadframe 200 has first and second sets of leads 210, 215. Although leads are discussed, other conductors can be used, such as lead fingers, and are considered within the scope of the invention. The first set of leads 210 extends from a first end 220 to a second end 230, and the second set of leads 215 extends from the first end 220 to a third end 225. For the first set of leads 210, the first end 220 is substantially perpendicular to the second end 230. For the first and second set of leads 210, 215, the first end 220 is for electrically coupling with an electronic system, such as a printed circuit board. The

first end can be coupled using reflow solder and other methods as known by those skilled in the art. The second end 230 of the first set of leads 210 and the third end 225 of the second set of leads 215 are adapted for coupling with a semiconductor die, as will be discussed further below.

In one embodiment, a portion of each lead of the first set of leads 210 has a generally arcuate shape, as the lead 210 extends radially from the first end 220 to the second end 230. For some of the first set of leads 210, a substantial portion of the lead has a generally arcuate shape. The arcuate shape of each lead of the first set of leads 210 has a different arc length than the other leads of the first set of leads 210. In another embodiment, each lead of the first set of leads 210 is spaced and sized such that the line spacing between at least one lead, or alternatively each lead, remains constant from the first end 220 to the second end 230. Each lead of the second set of leads 215 extends substantially straight from the first end 220 to the third end 225.

Another embodiment is illustrated in Figure 3. A leadframe 300 has first and second sets of leads 310, 315. The first set of leads 310 extends from a first end 320 to a second end 330, and the second set of leads 315 extends from the first end 320 to a third end 325. In one embodiment, the first end 320 of each lead of the first set of leads 310 is substantially perpendicular to the second-end-330. For both the first and second sets of leads 310, 315, the first end 320 of each lead is for electrically coupling with a printed circuit board. The second end 330 of the first set of leads 310 and the third end 325 of the second set of leads 315 are adapted for coupling with a semiconductor die, as will be discussed further below.

In one embodiment, each lead of the first set of leads 310 has at least three segments 340. The segments 340 are disposed such that a portion of each lead of the first set of leads 310 has a generally arcuate shape between the first end 320 and the second end 330. The arcuate shape of each lead of the first set of leads 310 has a different arc length than the other leads of the first set of leads 310. The segments-340 are substantially straight, and are each substantially the same length and substantially the same width. In one embodiment, at least one of the segments 340 is substantially straight and has a different length. In another embodiment, at least one of the segments 340 has an arcuate shape as shown in Figure 5. Each lead of the second set of leads 315 extends substantially straight from the first end 320 to the third end 325. The segmented

leads provide a significant advantage since they are stamped, which is easier and less expensive to manufacture.

The leadframe 200 of Figure 2 and the leadframe 300 of Figure 3 are formed from a single sheet of material or thin strip which is etched or stamped into a predetermined shape for connection with a selected chip design. The leads off the die are substantially flat. However, the leads or sections of the leadframe that extend over the die may need to be upset or downset, depending upon where the parting line of the mold is formed. After encapsulation in plastic, portions of the leadframe extend out of the respective chip packages. In one embodiment, the leadframe extends out of the sides of the packages at a selected elevation which is determined in advance. These outwardly extending portions include the ends of the leads of a package. These leads may be ultimately bent for insertion into a suitable connector device.

As shown in Figure 4, a leadframe 400 is assembled into an integrated circuit package 405. A semiconductor die 460 comprises circuitry (not shown) formed centrally on the die 460 and a plurality of bond pads 465 formed around the periphery of the die 460. The semiconductor die 460 is mounted using LOC technology with additional support from the leadframe at the edge of the die opposite the bond pad (not shown). Electrically conductive wire bonding 480 is used to connect selected bond pads 465 on the die 460 to selected leads of the leadframe 400. A portion of each lead of the first set of leads 410 of the leadframe 400 is formed in a generally arcuate shape. In one embodiment, a portion of the first set of leads 410 extends radially from a first end 420 to a second end 430. Alternatively, the first set of leads 410 includes a plurality of segments for forming the arcuate shape.

In one embodiment, the leadframe 400, semiconductor die 460 and wire bonding 480 are enclosed in protective, electrically insulative material such that ends of the leads are exposed to allow connection to be made to other electrical components. In another embodiment, leadframe 400, semiconductor die 460 and wire bonding 480 are encapsulated in plastic, thereby forming the integrated circuit package 405.

An integrated circuit package including the leadframe according to the invention has reduced effective inductance and crosstalk relative to existing integrated circuit packages. Below are simulated inductances and resistances for the tightly radiused leads of the conventional right

angle leadframe shown in Figure 1 and the leads of the arcuate leadframe shown in Figure 2. The lead number refers to leads shown in figures 1 and 2. Like numbers in the figures indicate leads connecting between same locations on the die and same exterior connections.

TABLE 1

Lead No.	Prior Art Lead Figure 1 (nH Ohms)	Radiused Lead Figure 2 (nH Ohms)
1	10.30 .514	9.62 .452
2	9.38 .522	8.85 .466
3	8.71 .506	8.29 .451
4	8.08 .476	7.83 .432
5	7.32 .423	7.39 .409

The results in Table 1 reveal the decreased inductance for the present invention. The inductance and resistance of each lead is less for the arcuate leadframe and the segmented leadframe than in the tightly radiused leadframe. In particular, the longer leads experience the greatest improvement in using the arcuate leadframe and the segmented leadframe versus the tightly radiused leadframe.

Advantageously, the radiused leadframe provides for lower inductance, resistance, and capacitance of leads in a leadframe, as opposed to leads with tightly radiused corners. These factors are important when the leads are carrying high-frequency signals; or signals having high-frequency harmonics, such as sub-nanosecond rise times. The continuous arcuate shape of the leads and the constant width of the leads maintains line spacing between the leads. This consistency maximizes layout space of the leadframe without increasing crosstalk. In addition,

a single leadframe strip or assembly can comprise leadframes for any number of a predetermined number of chips.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled.